



## **Update of Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias (International Endohernia Society (IEHS)) - Part A**

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# Update of Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias (International Endohernia Society (IEHS)): Part B

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## Abstract

In 2014 the International Endohernia Society (IEHS) published the first international “Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias”. Guidelines reflect the currently best available evidence in diagnostics and therapy and give recommendations to help surgeons to standardize their techniques and to improve their results. However, science is a dynamic field which is continuously developing. Therefore, guidelines require regular updates to keep pace with the evolving literature.

**Methods** For the development of the original guidelines all relevant literature published up to year 2012 was analyzed using the ranking of the Oxford Centre for Evidence-Based-Medicine. For the present update all of the previous authors were asked to evaluate the literature published during the recent years from 2012 to 2017 and revise their statements and recommendations given in the initial guidelines accordingly. In two Consensus Conferences (October 2017 Beijing, March 2018 Cologne) the updates were presented, discussed, and confirmed. To avoid redundancy, only new statements or recommendations are included in this paper. Therefore, for full understanding both of the guidelines, the original and the current, must be read. In addition, the new developments in repair of abdominal wall hernias like surgical techniques within the abdominal wall, release operations (transversus muscle release, component separation), Botox application, and robot-assisted repair methods were included.

**Results** Due to an increase of the number of patients and further development of surgical techniques, repair of primary and secondary abdominal wall hernias attracts increasing interests of many surgeons. Whereas up to three decades ago hernia-related publications did not exceed 20 per year, currently this number is about 10-fold higher. Recent years are characterized by the advent of new techniques—minimal invasive techniques using robotics and laparoscopy, totally extraperitoneal repairs, novel myofascial release techniques for optimal closure of large defects, and Botox for relaxing the abdominal wall. Furthermore, a concomitant rectus diastasis was recognized as a significant risk factor for recurrence. Despite still insufficient evidence with respect to these new techniques it seemed to us necessary to include them in the update to stimulate surgeons to do research in these fields.

**Conclusion** Guidelines are recommendations based on best available evidence intended to help the surgeon to improve the quality of his daily work. However, science is a continuously evolving process, and as such guidelines should be updated about every 3 years. For a comprehensive reference, however, it is suggested to read both the initially guidelines published in 2014 together with the update. Moreover, the presented update includes also techniques which were not known 3 years before.

**Keywords** Update Guidelines · Abdominal wall hernia · Ventral hernia repair · Primary ventral hernias · Secondary ventral hernias · Open sublay repair · Endoscopic sublay · Laparoscopic repair · IPOM · Rectus diastasis · Milos · Emilos · eTEP

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Extended author information available on the last page of the article

## Content Part B

- Chapter 1 How can the new techniques for minimal invasive extraperitoneal mesh repair of abdominal wall hernias and rectus diastasis be defined?
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## Introduction

Treatment of abdominal wall hernias is a rapidly evolving field of surgery. Correspondingly there is a dramatic increase of publications. There are many reasons for this development: rise of the number of laparotomies and the number of major surgeries being performed, progress in anesthesiology, increase of older patients with weak connective tissue, increase of patients with risk factors for hernias, and significant increase of patients managed with an open abdomen in a damage-control situation. Worldwide as many as two million patients are operated on every year. A variety of new repair techniques came up, recently even robot-assisted operations. The surgical approach may be open, laparoscopic, endoscopically within the abdominal wall, or hybrid approaches combining these modalities. The volume of literature, often with low levels of evidence and conflicting results, can be difficult to interpret in a meaningful way to assist the surgeon in appropriate management of the hernia patient. Therefore, there is a need for evidence-based guidelines to help the surgeon in his daily decision making process. “Guidelines are the bridge between science and clinical practice (Eccles M, Mason J. *Health Technol Assess*. 2001; 5(16):1–69. Review.). In 2014 this same group (IEHS) published the first international “Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias” [1, 2, 3]. It is generally accepted that guidelines require an update every 3 years to reflect the rapid evolution of techniques, materials and data available. The current update follows the same methodology as described in the original guidelines. The authors were encouraged to avoid redundancy and concentrate on

the new studies showing a level of evidence 1, 2 and 3, and which were published between 2012 and 2017. Statements and recommendations which are still valid are not repeated. As such, this update should be read in the context and in conjunction with the initially published guidelines. New topics included in this update are: In which patient group is a component separation indicated? Should the component separation be done open or endoscopically? Is an anterior component separation better than the posterior one? Is preliminary treatment with Botox indicated in patients in whom a component separation is planned? Should TAR be done open or endoscopically? In patients presenting with a ventral hernia in combination with a rectus diastasis which is the best treatment option? Does robot-assisted surgery have a future in repair of primary and secondary ventral hernias? What is the optimal treatment of lateral primary or incisional hernias? We are well aware that with respect to these innovations the evidence is not yet strong enough to give valuable statements or recommendations, however, the guidelines should inform the surgical community and stimulate further studies to gain more knowledge in the coming years.

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## **Chapter 1. Key question: how can the new techniques for minimal invasive extraperitoneal mesh repair of abdominal wall hernias and rectus diastasis be defined?**

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### **Methodology**

Search of MEDLINE, Embase, PubMed, PubMed Central, The Cochrane central registry of controlled trials (CENTRAL), Google Scholar, and Springer Link

### **Search terms**

“incisional hernia”, “abdominal wall hernia”, “laparoscopic sublay repair”, “endoscopic sublay mesh repair”, “endoscopic preperitoneal mesh repair”, “laparoscopic preperitoneal mesh repair”, “laparoscopic extraperitoneal mesh

repair”, “sublay mesh repair”, “preperitoneal mesh repair”, “retromuscular mesh repair”, “endoscopic retromuscular mesh repair”, “laparoscopic retromuscular “ventral hernia”, “laparoscopic ventral hernia”, “endoscopic ventral hernia”, “laparoscopic umbilical hernia”, “ELAR”, “MILOS”, “EMILOS”, “eTEP”, “rTAPP ventral hernia”, “rRives hernia”, “TAR”, “rTAR”, “Stapler Abdominoplasty”, “stapled closure”, “Robotic”, “midline augmentation”, “midline reconstruction”, “Rectus diastasis”, “minimal invasive ventral hernia”, “minimal invasive incisional hernia”, “minimal invasive abdominal wall hernia”.

### **Included publications**

Covering the period from 2003 to February 2018, using the search terms “abdominal wall hernia”, “ventral hernia”, and “incisional hernia” identified 12,507, 9971, and 3806 articles, respectively. One hundred and forty-three articles were identified for “rectus diastasis”. These were refined to 89 studies. In total, 30 studies were found to be relevant. Twenty-three were included in formulating these guidelines while 7 were excluded for language (2), open technique (2), or low quality (3).

Table 1 Classification of new techniques for minimal invasive extraperitoneal mesh repair of abdominal wall ventral hernias

## Access:

- Laparoscopic transabdominal preperitoneal (ventral TAPP)
- Laparoscopic transabdominal retromuscular (ventral TARM)/ Laparoscopic retromuscular ventral hernia repair (RMVH)
- Total extraperitoneal preperitoneal / retromuscular (ventral TEP)
- Enhanced view total extraperitoneal preperitoneal / retromuscular (ventral eTEP)
- Robotic Enhanced view total extraperitoneal preperitoneal / retromuscular (ventral reTEP)
- Robotic Transabdominal preperitoneal (ventral rTAPP)
- Robotic Transabdominal retromuscular (ventral rTARM)/ Robotic retromuscular ventral hernia repair (rRMVH)
- Transhernial total extraperitoneal/ preperitoneal / retromuscular Mini or Less-Open Sublay repair (MILOS) or endoscopic variant (EMILOS)

## Location of mesh:

- preperitoneal
- retrorectus (between rectus abdominis muscle and posterior rectus sheath)
- retromuscular (posterior to rectus abdominis or oblique muscles and peritoneum)
- onlay

## Modality of defect closure:

- Suture
- Tack
- Linear stapler
- None

## Reconstruction of the abdominal wall: closure of hernia defect, posterior rectus sheath, and rectus diastasis

- No closure
- Only closure of hernia defect
- Only closure of posterior rectus sheath
- Closure of hernia defect and posterior rectus sheath
- Closure of hernia defect and rectus diastasis
- Closure of hernia defect, posterior rectus sheath and rectus diastasis

## Simultaneous Minimally invasive posterior component separation (TAR) possible:

- Laparoscopic ventral TAPP, TARM, RMVH, TEP, eTEP: yes
- Robotic TAPP, robotic eTEP: yes
- MILOS, EMILOS: yes
- ELAR, Onlay: no

## Evidence of new minimal invasive extraperitoneal mesh repair techniques

### Statements:

Level 3	Total Extraperitoneal Preperitoneal (TEP) ventral hernia repair may be used to correct small and medium size ventral hernias.
Level 4	Endoscopic-assisted Linea Alba Reconstruction (ELAR) with mesh augmentation may be used to correct ventral hernias and coexisting diastasis with wide extraperitoneal mesh augmentation and favorable outcomes regarding recurrence, complications, and pain.
Level 4	Laparoscopic transabdominal preperitoneal and retromuscular ventral hernia repair (ventral TAPP and TARM = RMVH) may be used to correct small and medium size ventral hernias and coexisting diastasis with wide extraperitoneal mesh augmentation, minimal fixation, and favorable outcomes regarding recurrence, infection, and pain. With large ventral hernias, ventral TAPP and RMVH operations can be combined with posterior component separation (TAR).
Level 4	Enhanced-view Total Extraperitoneal Preperitoneal (eTEP) ventral hernia repair may be used to correct ventral hernias and coexisting diastasis with wide extraperitoneal mesh augmentation, minimal fixation, and favorable early outcomes regarding recurrence, infection, and pain. With large ventral hernias, eTEP operations can be combined with posterior component separation (TAR).
Level 2B	Minimally invasive Less Open Sublay (MILOS) and its endoscopic variants (EMILOS) effectively repair ventral hernias and coexisting diastasis with wide extraperitoneal mesh augmentation, minimal fixation, and favorable outcomes regarding recurrence, infection, and pain. With large ventral hernias, MILOS and EMILOS operations can be combined with posterior component separation (TAR).
Level 3	Robotic Retromuscular Hernia Repair (RRVHR) may be used to repair ventral hernias and coexisting diastasis with wide extraperitoneal mesh augmentation, minimal fixation, and favorable outcomes regarding fascial closure, recurrence, and length of stay but greater seroma rates and utilization of myofascial release. With large ventral hernias, RRVHR operations can be combined with posterior component separation (TAR).
Level 4	Linear cutting staplers may simplify and speed the creation of the retromuscular pocket and plicate a coexisting diastasis during extraperitoneal hernia and rectus diastasis repairs (MILOS, EMILOS, eTEP, TAPP).

## Recommendation:

Grade C	Several minimally invasive laparoendoscopic and robotic options for extraperitoneal mesh repair of ventral hernia with favorable short term outcomes can be offered. Ongoing evaluation regarding long term outcomes, operative time, cost, and clinical benefit are needed. The new techniques should only be adopted after adequate training.
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**Key question**

In patients presenting with a ventral hernia in combination with a rectus diastasis, which is the best treatment

option- IPOM plus, ELAR, MILOS, EMILOS, LIRA, eTEP, Stapler Abdominoplasty?

## Statements:

Level 2A	With regards to isolated Rectus Diastasis, no clear distinction in recurrence rate, postoperative complications, or patient reported outcomes can be made regarding plication as compared to hernia repair methods.
Level 3	Coexisting Rectus diastasis significantly increases hernia recurrence rate (31 vs 8%) while closure with non-absorbable sutures and mesh repair decrease recurrence.
Level 3	Mesh reinforcement is safe and durable for repair of large rectus diastases and those with concomitant hernia.
Level 2B	Plication of the Linea Alba during concurrent hernia and rectus diastasis repair reduces the average distance between the rectus muscles and may provide a functional and aesthetic benefits.
Level 2A	Laparoscopic IPOM ventral hernia and rectus diastasis repair with midline mesh augmentation and defect closure (IPOM plus) results in less recurrence, seroma and bulging.
Level 3	Laparoscopic intracorporeal rectus aponeuroplasty (LIRA) with mesh augmentation may be used to correct ventral hernias with coexisting diastasis with favorable outcomes regarding recurrence and pain.
Level 3	Novel extraperitoneal ventral hernia repair techniques with mesh augmentation (MILOS, eMILOS, eTEP, ventral TAPP, robotic eTEP, robotic TAPP, robotic RRVHR) may be utilized to repair ventral hernias with coexisting rectus diastasis.

## Recommendations:

Grade B	Mesh reinforcement of ventral hernia repairs with a concomitant rectus diastasis is recommended.
Grade B	In laparoscopic IPOM repair of ventral hernia and concurrent rectus diastasis, reconstruction of the linea alba with mesh augmentation should be performed when possible.
Grade C	Several novel minimally invasive endoscopic, laparoscopic, and robotic options for extraperitoneal mesh repair of ventral hernia with concomitant rectus diastasis can be offered. Ongoing evaluation regarding long term outcomes, operative time, cost, and clinical benefit are needed.

## Introduction

Laparoscopic intraperitoneal onlay mesh (IPOM) repair and open sublay mesh repair are currently the most common techniques for the treatment of primary and recurrent abdominal wall hernias worldwide [1–3]. A systematic review and two recently published meta-analyses concluded that laparoscopic IPOM and open abdominal wall hernia repairs are safe procedures with comparable short and long-term outcomes [1–3]. Although the open techniques are burdened with higher infection rates, laparoscopic IPOM repairs carry an increased risk of intraoperative bowel injury, adhesions, and bowel obstruction [1–4]. Despite progress in mesh technology and the development of coated meshes designed to lower the risk of adhesion formation, the potential risks associated with an intraperitoneal foreign body have not yet been eliminated [1–4]. Traumatic mesh fixation increases the risk of adhesions, visceral damage, nerve injury, and acute and chronic pain. Reduction of the hernia sac with closure of the hernia defect is difficult with laparoscopic IPOM, and is often omitted leading to higher recurrence rates, eventrations (pseudorecurrences), and seroma formation [5–8]. In larger hernias with a diameter of more than 15 cm, the laparoscopic IPOM repair can be very difficult [1–7].

To address the limitations of traditional laparoscopic and open ventral hernia repair, several minimally invasive endoscopic, laparoscopic, and robotic extraperitoneal techniques have developed with the goal of combining the benefits of traditional open sublay repair removing prosthetics out of the visceral compartment with those of minimally invasive surgery. The new minimal invasive extraperitoneal techniques can be classified according to access, mesh location, modality of defect closure, and anatomic reconstruction of the abdominal wall. In all of these novel procedures, standard uncoated permanent synthetic meshes (Polypropylene, PVDF, Polyester) may be used. Analogous to the differentiation in laparoscopic inguinal hernia repair, laparoscopic transabdominal techniques (ventral preperitoneal TAPP, ventral transabdominal retromuscular TARM/RMVH) can

be differentiated from endoscopic total extraperitoneal procedures (ventral TEP, eTEP, MILOS, EMILOS). Most of these novel extraperitoneal operations can be combined with posterior component separation (transversus abdominis release—TAR) as needed to address larger defects or accommodate larger prostheses. The first article on minimal invasive extraperitoneal mesh repair of ventral hernias was published by Miserez et al. [8]. Subsequent development of transabdominal, total extraperitoneal, transhernial, and onlay techniques performed in mini-open, laparoscopic, and robotic fashion have expanded the minimally invasive extraperitoneal options for repair of ventral hernias and coexisting rectus diastasis. Classification details for these novel extraperitoneal repairs are shown in Table 1.

Patients with symptomatic umbilical, ventral, and incisional hernias and concomitant rectus abdominis diastasis represent a growing clinical problem and, as with isolated hernias, the ideal operative management of this complex hernia situation has not been defined. With regards to isolated rectus diastasis, defined as a thinning and widening of the linea alba, combined with laxity of the ventral abdominal wall musculature, controversy remains as to whether this pathology is cosmetic or functional due to the variation in severity, symptomatology, and the absence of strangulation risk found with hernias [9]. While physiotherapy can achieve a limited benefit with regards to size and symptoms with isolated mild rectus diastasis, surgery significantly improves abdominal wall function and pain regardless of operative technique employed and should be considered with diastasis wider than 3 cm [10]. Currently, both plication and hernia repair methods are used to repair isolated rectus abdominis diastasis with no clear distinction in recurrence rate, post-operative complications, or patient reported outcomes found in the literature [9, 10].

The presence of rectus abdominis diastasis and coexisting hernia presents a greater challenge as the weakened linea alba and ventral abdominal musculature increase the risk of hernia formation, compromise the integrity of the midline,



and complicate the repair of ventral hernias. Köhler et al. demonstrated that a coexisting rectus diastasis significantly increases hernia recurrence rate with primary sutured closure (31 vs. 8%) [11]. As such, well established principles from ventral hernia repair including primary closure with non-absorbable sutures and mesh repair should be utilized to decrease hernia and diastasis recurrence [11]. Mesh repair of ventral hernias is well established as safe reducing the recurrence rate significantly compared to suture repair. Based on the volume of Level 1 studies studying ventral hernia, mesh reinforcement of ventral hernia repairs with a concomitant rectus diastasis is recommended while studies specifically evaluating ventral hernia and rectus diastasis corroborate these findings [12].

While the role of defect closure with isolated ventral hernia is likely beneficial but still unestablished, mesh reinforcement with ventral hernia in the setting of a concurrent rectus diastasis is more clear [11]. Multiple studies utilizing several different operative repair techniques demonstrate that restoration of the linea alba during concurrent hernia and rectus diastasis repair is feasible and reduces the average distance between the rectus muscles with potential functional and esthetic benefits [13–26]. These studies include traditional laparoscopic intraperitoneal (IPOM) repair with defect closure, subcutaneous closure of the anterior sheath, endoscopic subaponeurotic closure of the anterior sheath, laparoscopic sutured linea alba closure, laparoscopic posterior sheath closure, and linear stapled closure techniques to address the separation of the linea alba prior to mesh hernia repair. Restoration of the midline with correction of the diastasis at the time of ventral hernia repair when possible may provide additional benefit with regards to abdominal wall function, pain, and cosmesis [5, 10, 13, 17, 22, 25].

With regard to specific technique, several of the new minimally invasive mini-open, endoscopic, laparoscopic, and robotic extraperitoneal ventral hernia repairs may simultaneously address a coexisting rectus diastasis. There is a paucity of data in the literature for many of these novel techniques and an absence of comparative data to establish superiority of any given technique. The current literature summarized in these guidelines support that these reported techniques are safe, feasible, and effective in shorter term studies but ongoing and future studies are need to establish a “best treatment option”.

Laparoscopic intraperitoneal onlay mesh (IPOM) repair is the best and longest studied minimally invasive ventral hernia repair technique. Palanivelu et al. described their “Venetian blind” technique in 2009 to address the cosmetic and functional implications of a coexisting rectus diastasis or bridged hernia defect demonstrating the feasibility and efficacy of closing the defect at the time of IPOM repair [13]. Multiple primary studies, meta-analyses, and systematic reviews have subsequently been performed demonstrating

the benefits of defect closure with midline mesh augmentation during IPOM repair with regards to recurrence, seroma, and “pseudorecurrence” or bulging [5–7]. Extrapolating the data from these consistent level 2A studies to concurrent rectus diastasis and ventral hernia repair, reconstruction of linea alba with mesh augmentation, is recommended and should be performed when feasible.

The minimally invasive Mini or Less Open Sublay Repair (MILOS) and its endoscopic variant (EMILOS) developed by Reinbold and colleagues utilize progressively smaller “mini ( $\leq 5$  cm) or less open (6–12 cm)” incisions and laparoendoscopic transhernial approaches to replicate the traditional open Rives-Stoppa retrorectus or retromuscular sublay reconstruction for ventral hernia repair [14–16]. This approach simultaneously addresses the midline linea alba correcting coexisting diastasis with wide midline mesh augmentation and minimal fixation. Reinbold et al. performed a prospective, propensity score matched study within the German Hernia Registry (Herniamed) comparing 615 MILOS incisional hernia operations to laparoscopic IPOM incisional hernia repair and open sublay repair [14]. MILOS repair was associated with significantly fewer postoperative surgical complications, general complications, recurrences, and less chronic pain versus IPOM repair. Significantly fewer postoperative complications, reoperations, infections, general complications, recurrences, and less chronic pain were found compared to open sublay repair. The MILOS technique reproduces the functional and physiologic aspect of an open retromuscular repair with the benefits of minimally invasive techniques. Schwarz et al. and Bittner et al. demonstrated that this technique can be endoscopically modified (EMILOS) with similar feasibility, efficacy, and favorable outcomes for ventral hernia and rectus diastasis repair [15, 16]. In large defects, the MILOS technique can be combined with a posterior component separation (TAR).

The Enhanced or Extended-view Total Extraperitoneal Preperitoneal (eTEP) approach developed by Daes has been used to perform midline and off midline ventral hernia repair augmenting the traditional preperitoneal space utilized in inguinal hernia repair to access almost any portion of the abdominal wall. With regards to ventral hernia with a coexisting rectus diastasis, this technique allows for midline closure of the linea alba and any diastasis with wide extraperitoneal mesh augmentation, minimal fixation, and may be combined with posterior component separation with release of the transversus abdominus muscle to access to the entire retromuscular plane. Belayansky et al. performed a retrospective multicenter review of 79 patients utilizing the eTEP approach demonstrating low complication rates, significantly improved pain and functionality scores using the Carolinas Comfort Scale, and low complication, infection, and recurrence rates [17]. While the operative approach may differ slightly, the eTEP technique is anatomically and

physiologically similar to the eMILOS technique demonstrating similar benefits and efficacy.

The Endoscopic-assisted Linea Alba Reconstruction (ELAR) with mesh augmentation developed by Koeckerling is based on the principles of the MILOS technique and utilizes an endoscopic subcutaneous approach with subsequent mesh augmentation and reinforcement to address ventral hernia defects with concurrent rectus diastasis [20]. This hybrid technique exposes the anterior layer of the rectus sheath from the xiphoid process to the subumbilical area, the medial segments of the anterior layer of both rectus sheaths are sutured to reconstruct the linea alba, and the resultant defect in the anterior layer of the rectus sheath is repaired by suturing a mesh to the anterior sheaths bilaterally to reconstruct the anterior abdominal wall. Koeckerling et al. reported low complication and reoperation rates (1.4%, 2 cases due to bleeding) with favorable early results regarding pain and recurrence in their series of 140 patients [18–20].

Laparoscopic intracorporeal rectus aponeuroplasty (LIRA) with mesh augmentation described by Gómez-Menchero et al. was designed to address some of the challenges and limitations of closing the defect with the IPOM plus technique which may increase pain, recurrence, or require component separation to counteract the tension created by midline fascial reapproximation [21]. The posterior rectus aponeurosis is laparoscopically opened lengthwise around the hernia defect to create two flaps. The flaps are then sutured closed and the repair reinforced with an IPOM mesh. In their series of 12 patients followed to 1 year, this novel technique achieves a reproducible, feasible, “tension-free” repair of ventral hernias with coexisting rectus diastasis with a low rate of postoperative pain and no reported recurrence, or bulging [21].

Despite its benefits, minimally invasive laparoscopic ventral hernia repair can be technically challenging especially with complex procedures such as component separation, transversus abdominis release, and suturing of the ventral midline. The need for high technical skill, dexterity, and proficiency may lead to variability with regards to clinical outcomes, complication rates, and adoption. The use of the robotic platform for ventral hernia has progressively increased due to the benefits of improved optics and visualization, superior ergonomics, and improved degrees of freedom and range of motion needed to perform precise suturing, adhesiolysis, dissection, and mesh positioning and fixation necessary for abdominal wall reconstruction. With regards to ventral hernias and coexisting rectus diastasis, the Robotic Retromuscular Hernia Repair (RRVHR) utilizes the same operative plane as the open Rives-Stoppa, MILOS, eMILOS, and eTEP ventral hernia repairs. Warren et al. compared their robotic retromuscular repair (53 patients) to traditional laparoscopic ventral hernia repair (103 patients) utilizing registry data from the American Hernias Society

Quality Collaborative. Robotic retromuscular repair facilitated facial closure and extraperitoneal mesh placement in the vast majority of cases (96.2 vs. 50.5%;  $p < 0.001$ ). Hernia size was similar but robotic operations were longer and myofascial release was performed in 43% of robotic operations. Direct hospital costs were similar between both groups while length of stay was significantly shorter after RRVHR (23). Robotic retromuscular ventral hernia repair enables a true abdominal wall reconstruction and allows for simultaneous correction of coexisting rectus diastasis with wide extraperitoneal mesh augmentation, minimal fixation, and favorable outcomes regarding fascial closure and recurrence [23].

The term “Stapler abdominoplasty” represents a technical modification of several extraperitoneal operative techniques for ventral hernia and rectus diastasis repair rather than a unique operative approach. Linear cutting staplers may be used to develop the retromuscular space and plicate a coexisting diastasis during extraperitoneal hernia and rectus diastasis repairs. Costa et al. introduced this technique using a laparoscopic transabdominal preperitoneal approach in 15 postbariatric patients with hernia and rectus diastasis demonstrating feasibility, simplicity, and low complication rates [7]. Stapled plication of the anterior rectus sheath and division of the linea alba into an anterior and posterior component may be used in conjunction with open Rives-Stoppa, MILOS, eMILOS, eTEP, and laparoscopic retromuscular repairs [24–26].

In general, the indication for repair of diastasis recti of the abdominal muscles is based upon cosmetic or functional impairment, as there is no risk of strangulation. However, the negative implication of a rectus diastasis on ventral hernias with regards to recurrence and complications warrants consideration of the optimal approach to address both disease processes simultaneously. In these cases, the morbidity and risk of larger, more complicated operations for typically smaller coexisting hernias must be considered. Currently, there are several novel minimally invasive endoscopic, laparoscopic, and robotic procedures to address ventral hernia with coexisting rectus diastasis that are feasible, safe, and effective. Future studies with long-term outcomes and comparative data will help to define optimal techniques for these coexisting pathologies.

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## Chapter 2. Is there an indication for operative treatment of diastasis recti without hernia formation?

**Mazen Iskandar MD, Dimitri Ranev, MD, and George Ferzli, MD**

The following search terms were used: “diastasis recti” or “diastasis rectus” or “diastasis of the recti” or “diastasis of the rectus” or “rectus diastasis” or “rectus abdominis diastasis” or “divarication”. A systemic review of the literature was done in September 2017. A total of 219 papers were found. After selecting relevant studies, 20 articles were used for this review.

### Statements

- Level 2 Surgical correction of diastasis recti improves functional ability and quality of life compared to a supervised exercise program.
- Level 2 There is a weak association between diastasis recti and pelvic organ prolapse. Diastasis recti may be associated with impaired health-related quality of life, impaired abdominal muscle strength and low back pain severity.
- Level 2 Linea alba plication and retro-muscular mesh repair have equivalent results

### Recommendations

- Grade B Patients with significant diastasis and associated functional impairment should be offered surgical repair.
- Grade D Minimally invasive approaches can be considered, as they are safe and effective.

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### Introduction

Diastasis recti is a diagnosis that surgeons have to manage on a regular basis. It is simply described as bulging of the linea alba with increased intra–intra-abdominal pressure. Typically, women during pregnancy develop diastasis recti which regresses within a year after child birth. However, in a third of those patients, the diastasis persists [1]. The

width of the linea alba is measured at 2 reference points. The first is at 3 cm superior to the umbilicus and the second is 2 cm inferior. A patient is considered to have diastasis if the width between the 2 medial edges of the recti is greater than 22 mm at the first reference point and greater than 16 mm at the second point [2]. Nahas proposed a classification that included 4 types of “myofascial deformities” with a tailored treatment for each type [3]. In addition to diastasis recti, these types took into consideration other factors such as the appearance of the waist line and the presence of lateral laxity. Most women with diastasis recti after pregnancy fall under type A and are treated with plication of the anterior rectus sheath.

### Indications for surgery

Diastasis recti, even when associated with significant protrusion, does not represent a true hernia and poses no risk of incarceration or strangulation. Thus, the decision for surgery is based on functional and/or cosmetic impairment. In the majority of studies, repair is performed as part of abdominoplasty or ventral hernia repair [4–6].

In order to identify predictive factors for successful surgery, Strigård et al. correlated preoperative Ventral Hernia Pain Questionnaire scores with postoperative improvement in abdominal muscle strength. Patients were predominantly female (55/57) with median age of 43 years and median BMI of 23 kg/m<sup>2</sup>. The study found that pain while being seated for longer than 30 min and pain limiting the ability to participate in sports are preoperative predictors for successful surgery [7]. In another study by the same group of authors, patients were randomized between surgery and a training program supervised by a physiotherapist. Surgery resulted in significantly improved abdominal wall function compared to patients in the non-operative group [8].

Because the rectus abdominis muscles help stabilize the spine, researchers were interested in finding an association between diastasis recti and low back pain [9, 10]. After conducting a systematic review, Benjamin et al. concluded that there was a small association between diastasis recti and pelvic organ prolapse, and that diastasis recti may be associated with impaired health-related quality of life, impaired abdominal muscle strength and low back pain severity [10]. Whether there is an underlying connective tissue problem to explain the association remains unanswered.

### Surgical technique

Surgical options for treatment of diastasis recti include linea alba plication, modified hernia repair techniques, minimally invasive techniques (endoscopic or laparoscopic), or a combination of open and minimally invasive (hybrid) techniques. A systematic review by Mommers et al. included 1591 patients and failed to demonstrate a difference in outcomes among different surgical approaches [4]. Another two systematic reviews showed high patient satisfaction

after surgery, but no difference between the different surgical options [5, 6].

The largest randomized-controlled trial on diastasis recti by Emanuelsson et al. included 89 patients with diastasis > 3 cm [8]. Patients were randomized into three groups—plication in two layers using 2-0 barbed polydioxanone, repair with retromuscular polypropylene mesh or a supervised exercise program. The majority of patients (87/89) were female, with a median number of 2 prior pregnancies and a median BMI of 23. All patients were symptomatic and non-smokers. The study found no difference between the two surgical arms at 1 year follow-up, including improvement in abdominal wall function, quality of life, and complication rates.

### Choice of suture

Gama et al. conducted a randomized-controlled trial comparing linea alba plication in two layers versus one layer using non-absorbable suture (nylon). The study included 30 patients aged 25–50 years with a BMI 18–30 kg/m<sup>2</sup>. Patients with pre-existing hernia, significant comorbidities or smoking were excluded. The study found no difference in outcomes and a shorter operating time for the single-layer plication (35 vs. 15 min). Of note, there was an unacceptably high recurrence rate of 33% in patients in whom a barbed suture was used [11]. Another randomized study compared non-absorbable (nylon) with absorbable (polydioxanone) sutures for plication and found no difference in recurrence at 6 months. The study was limited by a small sample size—10 patients in each group—and the fact that it was sponsored by the company producing the absorbable sutures [12]. Mestak et al. performed a linea alba plication in 51 patients using running, locked, #0 loop polydioxanone. In a case–control study using ultrasound, they compared the postoperative inter-recti distance between the study group and a control group of normal subjects. There was no difference between the inter-recti distances of the study group and healthy subjects at 21 months follow-up [13].

### Minimally invasive techniques

In patients where excess skin removal and waist line definition are not needed, minimally invasive techniques become attractive. Endoscopic subcutaneous, laparoscopic, robotic, and hybrid approaches have been described as feasible and esthetically superior [14–20]. Traditionally, these approaches have been applied to diastasis associated with a hernia and often these repairs use mesh with or without the need for a fascial release. Endoscopic-assisted linea alba reconstruction (ELAR) is a hybrid approach where subcutaneous dissection is utilized to expose the anterior rectus sheath [17]. The anterior rectus sheath is released bilaterally and re-approximated to recreate the linea alba followed by augmentation with an onlay mesh. The endoscopic mini/less open sublay (EMILOS) technique is a hybrid procedure where the retromuscular space is dissected, the linea alba plicated followed by placement of a large mesh in the

retromuscular space as in a Rives-Stoppa repair [18]. The enhanced view totally extraperitoneal Rives-Stoppa (eTEP-RS) repair can be performed laparoscopically or robotically and, similar to the EMILOS approach, involves dissection of the retromuscular space, plication of line alba, and placement of a mesh [19]. Totally endoscopic subcutaneous dissection has also been described utilizing 3 suprapubic trocars. Following dissection, the linea alba is recreated with or without placement of an onlay mesh. [20]

However, there are no prospective studies comparing open and minimally invasive techniques. Published systematic reviews report no difference in outcomes, but are limited by low-quality data and high heterogeneity [4–6]. Since the indication for surgery in the majority of patients is cosmesis, a minimally invasive approach is the logical evolution in the surgical management of this condition when excess skin removal is not required.

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### Chapter 3. Component separation techniques

Frederik Berrevoet, Lars Nannestad Jorgensen

#### Background

Large ventral and incisional hernias, sometimes with loss of domain, remain a surgical challenge. Due to their relative rarity there is no exact estimate of their incidence. In 1951 Albanese et al. designed a first model of component separation of the abdominal wall, later elegantly refined by Ramirez in 1990 as a part of a study on human cadavers [1, 2]. The latter's initial results showed the possibility of translating the abdominal midline on average 10 cm per side at the umbilical level when releasing the external oblique muscle. Component

separation has been applied increasingly and modifications trying to tackle the main issues of the technique have been made. Described limitations of this technique are complications involving the skin and subcutaneous tissue, most likely caused by surgical interruption of perforating vessels during exposure of the oblique muscle [3]. To date, most commonly used techniques for releasing the various fascial components of the abdominal wall are the 'open anterior approach', the 'transversus abdominis release' (TAR), the 'endoscopic anterior release', and the 'open anterior perforator preserving approach' with their original description in the noted references [2, 4–6].

As the component separation techniques (CST) were not included in the former IEHS guidelines, a full literature search was performed.

#### Key question

1. When is any type of component separation indicated?

#### Search terms

The following search terms were used: ((component\* separation) OR (separation of components) OR (myofascial release)) AND (hernia OR (abdominal wall) OR ("Hernia, Ventral"[Mesh])) AND (indication OR use).

#### Search machines

PubMed, Medline, and the Cochrane Library as well as Google scholar were searched for relevant studies.

Abstracts of resulted articles were reviewed for their relevance to component separation techniques and indications. In total 475 papers were analyzed, of which none specifically studied indications for CST.

#### Indications for CST

#### Statements:

Level 3	Based on heterogeneous data, CST seem indicated in patients with large hernia defects.
Level 5	The hernia width diameter for which CST are indicated remains to be determined, (but 8-10 cm seems an acceptable value)
Level 4	Contaminated fields might be an indication for CST to primarily close the abdominal wall.
Level 3	CST are best combined with the use of mesh to reduce recurrence rates.
Level 4	Indications for CST as compared to other approaches to treat large abdominal defects remain to be defined.
Level 5	CST can be indicated in cases of open abdomen treatment.

## Recommendations:

Grade B	CST should be used to obtain fascial closure in large midline hernias.
Grade B	CST should be used in combination with mesh reinforcement whenever possible.
Grade C	CST should be considered to obtain fascial closure in contaminated fields, when no mesh is used.

Current literature on CST is heterogeneous in various aspects: indications for use, mesh augmentation versus primary fascial closure using CST, different surgical techniques, and different abdominal wall components to be separated. No well-designed randomized-controlled trials are available for most indications and comparative studies between CST other popular techniques to treat giant hernias with or without loss of domain, like the use of botoxulin A and progressive pneumoperitoneum are also non-existing. The majority of reported cases for CST involve large ventral hernia defects in which primary closure of the fascial edges is not possible and for which CST seems more efficient than bridging of the defect with mesh [8]. However, the definition of ‘large’ defects also varies considerably among publications. Slater et al. defined a large defect as a hernia width of at least 10 cm [9], but failure of primary closure of the fascia might occur with smaller defect as well, mostly due to fibrosis, edema, or obesity.

Among others, de Vries-Reilingh et al. and Hodgkinson et al. showed that CST might facilitate primary fascial closure in patients with contamination of the abdominal cavity, especially in case no mesh will be used [10, 11]. However, the same Dutch group of de Vries-Reilingh observed a high recurrence rate after CST without the use of mesh, which was confirmed by other groups [12, 13].

Another possible indication for the use of CST might be the open abdomen patient. Although the number of patients reported is very low, CST might increase the fascial closure rate in this specific subset of patients (refs).

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### 1. Key question

Which type of anterior CST is preferred?

### Search terms

The following search terms were used: ((component\* separation) OR (separation of components) OR (myofascial release)) AND (hernia OR (abdominal wall) OR (“Hernia, Ventral”[Mesh])) AND (indication OR use).

### Search machines

PubMed, Medline, and the Cochrane Library as well as Google scholar were searched for relevant studies.

Abstracts of resulted articles were reviewed for their relevance to the different component separation techniques. From the total of 475 papers extracted, 7 reviews [1–7] and 12 case–control studies [8–19] were applicable to the key question.

### Statements:

Level 3	Compared to open anterior component separation (OaCS), endoscopic (EaCS) or open minimally invasive perforator-sparing anterior component separation (MlaCS) result in a lower incidence of wound morbidity.
Level 3	OaCS, EaCS and MlaCS are associated with comparable rates of fascial closure.
Level 3	OaCS, EaCS and MlaCS are associated with comparable hernia recurrence rates.
Level 3	Total costs are not increased by EaCS or MlaCS.
Level 3	Indications for EaCS as compared to MlaCS remain to be defined.

### Recommendations:

Grade B	For fascial closure of large midline hernias, surgeons should consider EaCS or MlaCS, as an alternative to OaCS, in order to reduce postoperative wound morbidity .
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Various systematic reviews and meta-analyses have recently been reported to compare the different techniques of CST. The minimal invasive and endoscopic component separation have been suggested to reduce the postoperative wound morbidity as large subcutaneous dissection and skin flaps might be avoided achieving the same outcomes in terms of fascial closure rate.

In 2014 Feretis et al. reported 13 studies in their meta-analysis including 220 patients [3]. Overall they analyzed a wound complication rate of 17.5% versus 28% for endoscopic CST and Minimally Invasive CST respectively, resulting in a overall rate of 19.2%. However, when they only analyzed comparative studies, only 2 out of 5 studies [10, 12] showed a significantly lower incidence of wound morbidity in endoscopic and minimally invasive CST compared to open techniques, and the trend was clear in all studies [11, 13, 15]. This was confirmed by the systematic review of Switzer et al. who studied 63 studies including over 3000 patients with a wound complication rate of 34.6% for open versus 20.6% for endoscopic or minimally invasive techniques [2]. Jensen et al., in their review, only looked at studies that used the endoscopic CST as described by Rosen in 2007 [20] comparing it with the classical open Ramirez' technique [21]. In total 5 retrospective cohort studies were observed with 163 patients, but again 43% versus 18% of wound morbidity was seen, in favor of the endoscopic CST [1].

Cornette et al., although analyzing the various anterior CST versus the posterior CST (TAR), found 13 studies for laparoscopic/endoscopic CST, only 5 on minimally invasive perforator sparing techniques and 22 on open CST. Considering wound morbidity, a slight trend in favor of perforator sparing techniques was found, versus open and laparoscopic techniques (16% vs. 21.4% and 20.3% respectively). However, as this trend is consistent throughout all the available data, despite their moderate to low quality, surgeons should consider endoscopic or minimally invasive (perforator sparing) CST, as an alternative to open CST, in order to reduce postoperative wound morbidity. Regarding recurrence rates after these various modalities, no differences are observed in the current medical literature. Furthermore, it is difficult to draw any conclusions regarding this parameter, as many variables influence recurrence rate in these large hernias.

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## 2. Key question

Is a Transversus Abdominis Release (TAR) preferred over an anterior component separation technique?

## Search terms

The following search terms were used: ((component\* separation) OR (separation of components) OR (myofascial release)) AND (hernia OR (abdominal wall) OR (“Hernia, Ventral”[Mesh])) AND (anterior OR posterior).

## Search machines

PubMed, Medline, and the Cochrane Library as well as Google scholar were searched for relevant studies.

Abstracts of resulted articles were reviewed for their relevance to the different component separation techniques. From the total of 106 papers extracted, 3 reviews [1–3] and 3 case–control studies [4–5] were applicable to the key question.

## Statements:

Level 3	EaCS and MlaCS result in a similar wound morbidity rate as a posterior Transversus Abdominis Release.
Level 3	EaCS and MlaCS result in a comparable recurrence rate as a posterior Transversus Abdominis Release.

## Recommendations:

Grade B	For intermediate to large defects, surgeons should consider EaCS, MlaCS or TAR as an alternative to OaCS in order to reduce postoperative wound morbidity.
Grade C	For lateral defects in need of a large mesh overlap, TAR should be preferred over anterior component separation techniques.

As a retromuscular mesh position in incisional hernia is still preferred over an onlay or intraperitoneal mesh repair, larger defects might be difficult to treat using this technique as the mesh overlap is limited by the lateral borders of the rectus sheet. Since the introduction of the posterior component separation technique using a transverses abdominis release (TAR), described by Novitsky et al., there is no need for large subcutaneous dissection to perform CST, and an extended wide overlap can be achieved for large defects and defects located lateral to the rectus muscles. Most of the literature involves retrospective observational cohort studies and not much comparative data are available. Recently, Hodgkinson et al. investigated the outcomes of posterior component separation and TAR with the open anterior CST. They report on 7 studies describing 281 cases of TAR for midline incisional hernia using a retromuscular mesh placement and compared those to 6 comparable studies describing 285 cases of open anterior CST and retromuscular mesh placement. Comparative analysis demonstrated no significant difference between hernia recurrence rate ( $p=0.23$ ) and no significant difference was found in wound complication rates between TAR and the open CST ( $p=0.53$ ). This finding was reported earlier already by Cornette et al. [2] and again confirmed recently by Scheuerlein et al. [3].

Therefore, surgeons are recommended to consider endoscopic, minimally invasive, or TAR as an alternative to OaCS in order to reduce postoperative wound morbidity. For lateral defects which may need a large mesh overlap, TAR should be preferred over anterior component separation techniques.

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#### Chapter 4. Key question: In which patient group is a transversus abdominis release (TAR) indicated?

##### G Woeste, A de Beaux

The main goal of ventral hernia repair is reconstruction of the midline and bringing the rectus muscle together.

The recurrence rate has shown to be significantly lower when a bridging of the gap with the used mesh can be avoided [1].

A restoration of the midline is beneficial both in terms of functional results and recurrence rate.

Whenever it is not possible to close the linea alba in midline ventral hernia repair, a component separation technique (CST) is indicated. The TAR technique can be used to achieve midline closure in most of the cases. With an advancement of 8 to 12 cm per side Novitsky et al. have reported a closure rate of 97.2% [2]. When a recurrent hernia occurs after an anterior component separation (aCS) has been performed TAR has been shown to be an option for abdominal wall reconstruction in these complex cases [3]. However, it is an import rule that aCS and TAR should never be performed simultaneously at the same side.

Apart from midline incisional hernias TAR can be used for the repair of lateral hernias (L1–4). A case series of hernias after kidney transplantation has been published with low morbidity and low recurrence rate [4].

Also a cohort of parastomal hernias has been successfully treated by stoma relocation and closure of the lateral hernia using TAR (5).

#### Statements:

Level 4	TAR is effective in reconstruction of the abdominal wall in wide midline hernias (M1-5, W3) as well as in lateral hernias (L1-4).
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## Recommendations:

Grade C	TAR can be applied for abdominal wall reconstruction to achieve restoration of the midline in complex ventral hernias (M1-5, W3)
Grade C	TAR can be used for recurrent hernias following previous anterior component separation.
Grade C	TAR can be used for lateral hernia repair (L1-4)

**References** (in parentheses the level of evidence)

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**Should the TAR be done open or endoscopically?**

The open TAR technique has first been described by Novitsky in 42 patients with complex hernias with a mean defect size of 366 cm<sup>2</sup> [1].

The largest series of open TAR (O-TAR) is published by the same author [2]. In this retrospective series of 428 patients the incidence of surgical site events was 18.7% with 9.1% SSI and no mesh removal. The recurrence rate after 1 year was only 3.7%. Winder et al. described similar results in their retrospective review of 37 patients with 5.4% SSI and 2.7% recurrences at 2 years only in patients where a midline closure could not have been achieved [3].

The laparoscopic technique of TAR has been published in 2016 with a cohort of 3 patients showing no complications [4].

Also a robotic (rTAR) approach has been described [5].

The published results of rTAR are very limited. A nationwide series of 6 patients in Brazil has been described [6]. The authors conclude that this technique is feasible with two postoperative complications requiring reoperation.

No randomized-controlled trials comparing open and laparoscopic or robotic TAR are published so far. Two retrospective studies compare the results of O-TAR and rTAR.

The Cleveland group compared 38 patients who underwent rTAR with a matched historic cohort of 76 O-TAR cases [7]. Comparing the patient characteristics, more ASA III patients were found in the O-TAR group. The robotic approach showed significant longer OR time ( $299 \pm 95$  vs.  $211 \pm 63$ ,  $p < 0.001$ ). The incidence of wound morbidity did not show any significant difference between the two techniques for both SSE and SSI. The rTAR group showed lower blood loss ( $49 \pm 60$  ml vs.  $139 \pm 149$  ml,  $p < 0.001$ ), less systemic complications (0 vs. 17.1%,  $p = 0.026$ ), and a shorter hospital stay ( $1.3 \pm 1.3$  days vs.  $6.0 \pm 3.4$  days,  $p < 0.001$ ).

A retrospective review of 102 patients, 26 rTAR and 76 O-TAR, were compared by Bittner et al. [8]. Comparing the comorbidities, diabetes was more common in the O-TAR group (22.3% vs 0%,  $p = 0.01$ ). The defect size was comparable ( $260 \pm 209$  cm<sup>2</sup> vs.  $235 \pm 107$  cm<sup>2</sup>,  $p = 0.55$ ). In this cohort the OR time was significantly longer with rTAR ( $287 \pm 121$  vs.  $365 \pm 78$  min,  $p < 0.01$ ). The surgical site events were the same in both groups (6.6% vs. 7.7%,  $p = 1.0$ ). There was no significant difference in morbidity. The length of hospital stay was shorter after rTAR (3 vs. 6 days).

Level 3 Both open and minimally invasive TAR are safe procedures.

Level 3 rTAR is associated with longer operative time compared to O-TAR.

Level 3 rTAR can reduce postoperative length of hospital stay compared to O-TAR.

Level 3 O-TAR and rTAR show the same incidence of postoperative wound morbidity.

Grade C TAR can be performed open, laparoscopic and robotic

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## Chapter 5. Key Question: The role of preoperative adjunct interventions in ventral hernia repair

H. Hoffmann, P. Kirchhoff, J. Kukleta, W. Reinpold

### Search items

“Botox AND Hernia”, “Botulinum Toxin A AND Hernia”, “Component Separation AND Botulinum Toxin A”, “Component Separation” AND “Hernia”, “Progressive Pneumoperitoneum AND Hernia”

A systematic search of the available literature was performed in September 2017 of Medline, PubMed, Cochrane Library, and relevant journals and reference lists using the above-listed search terms. The search found 38 articles; however, only 26 studies were suitable for this review in terms of content.

### Statements

Level 3	BTA administration prior to VHR is associated with significantly less opioid analgesia use and significantly less pain.
Level 4	<p>Botulinum toxin A (BTA) prior to ventral hernia repair (VHR) facilitates a decrease in transverse hernia diameter, a significant reduction of lateral abdominal wall muscle thickness, and a significant elongation of lateral abdominal wall muscles.</p> <p>In majority of patients with large ventral hernias BTA administration alone enables direct fascial closure without additional component separation techniques.</p> <p>BTA has shown to be effect when administered under ultrasound guidance between four to six weeks prior to VHR in either three or five injection sites on each side.</p> <p>Despite BTA related side effect such as abdominal wall distension, impaired coughing and sneezing, BTA has been demonstrated to be safely administered prior to VHR without BTA related complications and adverse events.</p> <p>Before BTA administration national medication regulations should carefully be considered.</p> <p>Progressive pneumoperitoneum can increase the volume of the abdominal cavity by increasing the lateral abdominal wall muscle length, with the potential of tension free primary fascial closure. However, PPP related complications must be considered.</p> <p>Tissue expander have a potential as an adjunct in abdominal wall reconstruction, but device related complications must be considered.</p>

### Recommendations

Due to the low evidence of available data, no recommendations regarding the use of Botulinum Toxin A, progressive pneumoperitoneum and tissue expanders as adjunct interventions in ventral hernia repair in can be made.

### Introduction

Techniques such as progressive pneumoperitoneum (PPP), tissue expander (TE), and—most recently—Botulinum Toxin A (BTA) have gained some interest as an adjunct in the surgical approach of large incisional hernias, to gain primary fascial closure (PFC).

### Botulinum Toxin A

Botulinum Toxin A (BTA) is a neurotoxic protein produced by clostridium botulinum. The paralyzing effect reaches a maximum 2 weeks after topical administration and declines gradually after 2–3 months [1–3]. Several clinical studies investigated the effect of BTA on abdominal wall muscle parameters using CT scans. Ibarra-Hurtado et al. [4]

demonstrated a significant reduction of the transverse hernia defect in 12 patients. PFC was gained in six patients with BTA alone and with additional component separation (CS) in further six patients. In a subsequent study of 17 patients they demonstrated a significant reduction of lateral abdominal wall muscle thickness and the transverse hernia diameter, and a significant elongation of lateral abdominal wall muscles after BTA application [5]. PFC was possible in all patients, of which nine needed additional CS. Farooque et al. reported a significant increase in mean length of the lateral abdominal muscles post-BTA in a case series of 8 patients achieving PFC in all cases [6]. Also, Elstner et al. reported a significant increase in mean length of the lateral abdominal wall muscles in 27 patients, achieving PFC in all patients, with additional CS in six patients. Another study evaluated BTA administration in 56 consecutive patients undergoing VHR [7], of which 18 patients additionally underwent progressive pneumoperitoneum (PPP). They reported a significant increase in the lateral abdominal wall length. PFC was achieved in all patients, in 16% with additional CS. Another study from Elstner et al. investigated BTA and PPP administration in 16 patients with loss of domain undergoing VHR [8], achieving PFC in all patients without additional surgical dissection. Bueno-Lledó et al. performed a prospective observational study using BTA and PPP in 45 patients with loss of domain. They found a significant reduction of the VIH/VAC (volumes of the incisional hernia/volume of abdominal cavity) ratio by 14%. PFC was achieved in all patients with CS.

There are seven clinical studies reporting the effect of BTA administration alone regarding avoidance of additional CS techniques [4–7, 9–11]. In total 150 patients were enrolled in these studies, achieving PFC with BTA alone in 78% ( $n=117$ ). Considering that BTA reaches its maximum paralyzing effect after 2 weeks [1–3], timing of BTA application seems of somewhat importance. The available clinical studies follow different timing concepts ranging from the day of surgery up to 6 weeks prior to surgery [4–12]. Regarding supportive imaging guidance during BTA administration, majority of available studies report the use of ultrasound [5, 6, 8–12]. Only one study used musculature electromyography [4]. The injection volume, units, and concentration of BTA administration in VHR shows heterogeneity amongst available clinical studies. Three studies used 500 units of BTA in total [4, 5, 12]. Six studies used a total dose of 300 units BTA [6–11]. Regarding concentration and administered volume of BTA authors reported BTA concentration of 100 units/ml in 5 ml 0.9% saline solution [5], 10 units/ml in 50 ml in 0.9% saline solution [12] or 2 units/ml in 150 ml 0.9% saline solution [6–11]. Regarding injections sites, authors either perform three [6–11] or five [4, 5, 12] injections per side. Only one study investigated the effect of BTA administration on postoperative pain in a prospective

cohort of 22 patients with BTA administration prior to VHR compared with a historic matched control group ( $n=66$ ). Patients with BTA administration had significantly less pain when compared to controls [10]. Since BTA is neurotoxic, potential complications or adverse events (AE) related to BTA application need to be addressed before injection. Only one study reported side effects of BTA administration such as abdominal wall distension, impaired coughing, and sneezing [11], while the majority of available clinical studies reported no BTA related adverse events or complications [5–12].

There are three reviews investigating the effect of BTA in incisional hernia repair including 15 studies with 259 patients [13], 6 studies with 133 patients [14] and 3 studies with 56 patients [15], respectively. The reviews reported PFC rates of 100% [13] and 84% [14] and decreases in the ventral hernia defect size [15]. Due to the small sample sizes and heterogeneity of included studies and the lack of standardization of BTA administration the level of evidence remained low (3a).

### Progressive pneumoperitoneum

The concept of progressive pneumoperitoneum (PPP) was first described 1947 by Goni Moreno [16] and has been modified by other groups ever since. It consists of repeatedly inflating air into the abdominal cavity using sterile catheters over a few days, gaining an enlargement of the abdominal cavity to obtain hernia reduction and tension-free closure of large abdominal wall hernias. Since then a view case series and cohort studies with low number of patients have been published [13, 17–25]. All studies differ in terms of used gas for insufflation, patient population, timing, frequency, and volume of PPP insufflation. Investigated indications for PPP were giant incisional hernias [17–19, 23], large inguinal hernias [19] or patients with loss of domain [20–22, 24]. The timing of PPP insufflation showed differences among the available studies, starting at means between 5 and 15 days prior to surgery. PPP insufflation was repeated every day in some studies [19, 22, 23], other studies had longer insufflation intervals of 2 days or more [17, 18, 20, 21, 24]. The totally applied PPP volume ranged at means from 12 to 23 l with insufflation volumes of 1000–4000 ml per session. Adverse events (AE) were reported in most studies. Most frequent AE was shoulder pain in up to 24% [17, 18], limiting the amount of insufflated air. Bleeding complications [17, 18], catheter misplacement [17–19, 22], emphysema [19–21, 23], and catheter infection [22] have also been reported. However, PPP has been demonstrated to increase the volume of the abdominal cavity [17, 21, 24] by increasing the lateral abdominal wall muscle length [23]. As highlighted in a recent review [13], tension-free PFC after PPP in large ventral hernias was achieved in 84% of cases with a reported recurrence rate of 7.2%.



## Tissue expanders

The purpose of tissue expanders (TE) is to stretch skin or the underlying fascia allowing PFC in larger hernias. TE can be positioned subcutaneously in cases of skin loss, intermuscular between the external and internal oblique muscles in cases of large ventral hernias and intra-abdominal in cases of congenital abdominal wall defects [26]. There is no consensus regarding indications, optimal technique, and TE associated risks. Recent reviews with large heterogeneity regarding study design, study population, number of patients, indication, and position of TE [13, 26] demonstrated PFC rates of 93% using TE.

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## Chapter 6. Robotic ventral/incisional hernia repair

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### Key question

1. What are the differences between Robotic Intraperitoneal Onlay of Mesh (rIPOM) and standard IPOM?

The following search terms were used to identify the relevant literature on robotic ventral hernia repair in July 2018. Abstracts of resulted articles were reviewed for their relevance to robotic ventral hernia repair. “Robotic ventral hernia” search identified 60 articles, 26 of which were relevant after review of the abstract. “Robotic incisional hernia” resulted in a total of 59 articles, with 3 additional relevant studies identified. Six additional articles were found using “robotic TAR,” 2 of which were relevant and included. Search for “robotic transversus abdominis release” revealed no additional articles, nor did search for “robotic component separation.” Finally, “robotic abdominal wall reconstruction” identified 1 additional relevant publication included in this review.

### Introduction

Though first described in 2003 [1], there has been relatively little interest in robotic surgery for hernia repair until the last several years. Of 32 relevant articles in the published literature, 19 have been published in 2017–2018 alone. Technological interest, surgeon ergonomics, improved 3-dimensional visualization, and articulating instruments that greatly facilitate intracorporeal suturing and dissection are among the leading reasons for the exponential growth in robotic hernia repair. Disadvantages of the robotic platform are the loss of tactile feedback, relying entirely on visual cues, and intimate knowledge of tissue handling [2]. Additionally, cost can be significant barrier to utilization and allocation of health care resources [2–4]. Durability of various robotic repair techniques remains an unanswered clinical outcome. No studies to date have significantly long enough follow-up to determine hernia recurrence rates or other potential long-term complications. Several techniques have been described using the robot, including standard intraperitoneal onlay of mesh (rIPOM) similar to that of standard laparoscopic ventral hernia repair with intraperitoneal mesh (LVHR), transabdominal preperitoneal repair (rTAPP), retromuscular repair with or without transversus abdominis release (rRVHR or rTAR), and most recently a retromuscular repair using an extended totally extraperitoneal (eTEP) approach.

## Robotic Intraperitoneal Onlay of Mesh (rIPOM)

### Statements: rIPOM

Level 2c	Robotic IPOM results in similar rates of surgical site occurrences and infections compared to standard LVHR.
Level 3	Robotic IPOM results in shorter length of stay compared to standard LVHR, with similar rates of readmission, reoperation and other postoperative complications.
Level 3	Robotic IPOM reliably facilitates closure of the hernia defect.
Level 3	Operative time for rIPOM is significantly longer than standard LVHR.
Level 5	Robotic IPOM may result in decreased post-operative and chronic pain compared to standard LVHR with transfascial suture or tack fixation.

### Recommendations: rIPOM

Grade B	Robotic IPOM may be considered comparable to standard LVHR in most clinical outcomes at the expense of increased operative time. Follow-up is insufficient, to adequately compare risk of hernia recurrence.
Grade C	Robotic IPOM improves the ability to close the hernia defect during minimally invasive hernia repair.
Grade C	Hospital LOS may be reduced with rIPOM compared to standard LVHR. Studies lack appropriate methodology and power, with significant heterogeneity in technique and perioperative care, to clearly demonstrate the generalizability of this finding.

The majority of reported cases involve the use of the robot to perform a standard laparoscopic approach with placement of mesh in an intraperitoneal position, with the addition of standard closure of the defect. The primary benefit of this approach over LVHR is the ability to reliably close the hernia defect. The benefits of defect closure have been demonstrated in a number of studies, primarily in reducing the rate of seroma formation, and possibly reduction in hernia recurrence [5–10]. Abdominal wall tension required to close the hernia defect may be offset by additional transfascial suture fixation [11] or use of myofascial release [12, 13]. Comparative series of rIPOM vs LVHR indicate higher rates of fascial closure for robotic repair, but all are retrospective

series without a protocolized approach to defect closure [8, 14–17].

Operative time is significantly longer with rIPOM compared to LVHR in all four comparative trials [8, 15–17]. This is likely associated with the differences in technique, primarily in defect closure and suture fixation of the mesh rather than tacks, and the learning curve for robotic repair. Intracorporeal suture fixation of the mesh, rather than standard tack or transabdominal wall sutures, is often touted to reduce postoperative and chronic pain compared to LVHR [2, 3, 18]. While there is some evidence that traditional fixation techniques, and the use of transfascial sutures in particular, may lead to greater postoperative pain [19–22],

data are lacking to support this finding. There is, however, a consistently demonstrated reduction in hospital length of stay, which may be a surrogate marker for decreased early postoperative pain following rIPOM. The only comparative study evaluating pain as a specific secondary outcome showed no difference in narcotic use between LVHR and rRVHR/rTAR [14].

Rates of clinically significant wound complications are largely unaffected by rIPOM compared to LVHR. Rate of SSI is reported between 0.9 and 3.8%, with a single outlier study demonstrating a 9.1% rate of SSI (single patient in a case series of 11 patients) [2, 3, 12, 13, 18, 23, 24]. Surgical site occurrences are similarly low with rIPOM (0.9–3.8%) [2, 3, 12, 13, 18, 23, 24]. One study demonstrated a lower rate of SSO after rIPOM [17]. No differences were seen in patients requiring procedural intervention in the treatment of SSO or SSI in these studies. Overall complications were

procedures improving rates of readmission and LOS over OVHR [27]. This study also cannot account for specific surgical technique.

Hospital length of stay ranges from 0 to 2.5 days for rIPOM. Three of five comparative studies demonstrated a statistically significant difference in LOS [8, 14–16]. Prabhu et al. analyzed 186 rIPOM vs 452 LVHR in the Americas Hernia Society Quality Collaborative (AHSQC) database, demonstrating a reduction in LOS from 1 to 0 days with rIPOM ( $p < 0.001$ ) [15]. Alteiri et al. similarly demonstrated a shorter LOS after RVHR [25]. Warren et al. demonstrated a shorter median LOS with rRVHR compared to IPOM LVHR [14]. No inferences can be drawn regarding hernia recurrence due to lack of long-term follow-up.

#### **Robotic Transabdominal Preperitoneal Repair (rTAPP)**

##### Statements: rTAPP

Level 4	Mesh placed in an extraperitoneal position reduces the potential for long-term mesh-related complications, particularly in the event of subsequent abdominal operations.
Level 4	Robotic TAPP is safe and technically feasible for repair of small ventral hernias.
Level 5	Robotic TAPP may lessen the potential for long-term mesh-related complications of intraperitoneal mesh.

##### Recommendations: rTAPP

Grade D	Robotic TAPP is a safe and effective alternative to rIPOM or standard IPOM LVHR for small hernias.
Grade D	Robotic TAPP allows placement of mesh in an extraperitoneal position, which may reduce long-term mesh-related complications.

reduced for rVHR compared to LVHR after propensity score analysis from the New York State Planning and Research Cooperative System [25]. This study does not account for specific technique of RVHR, however. Similarly, evaluation of the National Inpatient Sample (NIS) demonstrates the safety and efficacy of rVHR, with similar rates of minor and major complications compared to LVHR [26]. Interrogation of the Vizient database demonstrated no benefit of rVHR over LVHR in clinical outcomes, with both

Placement of mesh in an extraperitoneal position may reduce long-term mesh-related complications compared to standard IPOM, particularly in the event of subsequent abdominal operations [28–33]. Laparoscopic TAPP repair of ventral hernia has been described, with favorable results [34, 35]. The delicate dissection of the peritoneum may be facilitated by robotic instrumentation. Three studies have been published to date examining the rTAPP approach. Sugiyama et al. used an rTAPP approach for repair of ventral hernia in

three patients. Mean operative time was 164 min, with no reported operative or perioperative complications. Orthopoulos et al. reported rTAPP repair in 54 patients. Mean OR time was 73 min, with two reported complications; a seroma requiring percutaneous drainage and rectus sheath hematoma resulting in readmission and transfusion [36]. Finally, Kennedy et al. compared 27 rIPOM to 36 rTAPP patients. Operative time was similar between groups, as were minor perioperative complications [37]. No inferences can be drawn regarding hernia recurrence due to lack of long-term follow-up.

**Robotic retromuscular ventral hernia repair (rRVHR), robotic transversus abdominis release (rTAR), and robotic extended totally extraperitoneal (eTEP)**

Perhaps the greatest promise for robotic hernia repair is the capability of this platform to duplicate an open retromuscular hernia repair, widely considered to be the standard for OVHR. The first description of this approach was reported in 2012 [38]. The potential advantage of this approach is the ability to utilize the robot to perform myofascial release of the rectus abdominis and/or transversus abdominis to facilitate medialization of the hernia defect for closure under reduced tension and placement of mesh in the retromuscular (extraperitoneal) space. The first study reporting outcomes of rRVHR/rTAR demonstrated a reduction in LOS compared to standard LVHR (1 vs. 2 days;  $p = 0.004$ ), with similar rates of SSI, SSO requiring procedural intervention (SSOPI), and reliable closure of the hernia defect. Operative time was

Statements: rRVHR / rTAR / eTEP

Level 2C	Robotic retromuscular ventral hernia repair with or without TAR significantly reduces hospital length of stay compared to open VHR (OVHR).
Level 3	Operative time for rRVHR / rTAR is significantly longer than OVHR or standard LVHR.
Level 3	Hernia defect closure and extraperitoneal mesh placement is reliably achieved with rRVHR / rTAR.
Level 4	Incidence of SSI may be reduced for RRVHR / rTAR compared to OVHR. Incidence of SSO is similar, with the majority of cases involving seroma requiring no procedural intervention.

Recommendations: rRVHR / rTAR / eTEP

Grade B	Significant reduction in LOS is possible with rVHR / rTAR and should be considered in patients with ventral / incisional hernias.
Grade C	Reduction in SSI may be achieved with rVHR / rTAR / eTEP, but larger studies are necessary to clearly demonstrate the significance of this outcome.
Grade C	Recurrence rates appear similar to OVHR and LVHR. However, long-term follow-up is lacking.
Grade D	eTEP approach may reduce the need for additional myofascial release compared to rTAR, which more closely approximates the stepwise approach for myofascial release as performed in OVHR.

significantly longer with robotic repair [14]. However, this comparison involved two very different hernia techniques for hernia repair. Comparison of rVHR/rTAR with open retromuscular repair is more appropriate. In the largest series to date, patients in the AHSQC undergoing rVHR or rTAR were compared to those undergoing open retromuscular VHR. After propensity score matching, 111 rVHR and 222 OVHR cases were identified. Groups were similar in hernia morphology and patient comorbidities. Robotic repair resulted in significantly shorter LOS compared to OVHR [39]. Two single-center comparative studies of rTAR to open TAR (O-TAR) were published this year. Martin del Campo et al. compared 38 rTAR to a matched cohort of 76 O-TAR, demonstrating a significant reduction in LOS from 6 to 1.3 days ( $p < 0.001$ ) with rTAR, and reduction in both SSO and SSI, though this did not reach statistical significance. Bittner, et al., compared 26 rTAR to 76 O-TAR. No difference was seen in SSO or SSI, though LOS was again significantly shorter after rTAR than O-TAR [40]. Operative time was significantly longer for rVHR/rTAR in each of these studies. No inferences can be drawn regarding hernia recurrence due to lack of long-term follow-up.

## Costs

### Statement: Costs

Level 3	Robotic requires significant capital expense, and is associated with higher cost compared to LVHR, and possibly higher direct cost than OVHR.
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### Recommendation: Cost

Grade D	Cost calculations are complex. Further study is needed to understand the cost of rVHR in its various forms and in relation to potential differences in clinical outcomes compared to laparoscopic and open repair.
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Inpatient Sample as well [26]. However, charges and cost are different measures and cannot account for complexity of health care costs. Cost can vary greatly from hospital to hospital depending on payment contracts, Group Purchasing Organizations, type of procedure performed, coding, and reimbursement. Internationally, the diversity of health care organization is such that a single study will likely be unable to truly predict cost to any individual hospital or health system.

### Conflict of interest

As with any new technology or technique, early literature must be interpreted in the context of the emerging technology itself, the larger changes in the given field of study, and the method of dissemination of the technique. Novel surgical techniques are quite often promulgated through industry, making author conflict of interest (COI) an important factor in interpreting the literature. In the case of rVHR, this is chiefly through Intuitive Surgical® as this has been the only available robotic platform available for clinical use until recently. Patel et al. published an analysis of payments

Cost is the factor most often used to critique robotic surgery across all disciplines. The capital cost of equipment alone often exceeds \$2 million, with additional costs for service contracts, disposables, and instruments. In their review of the Vizient database, Armijo et al. found the cost of rVHR significantly greater than LVHR or OVHR [27]. Charges for RVHR were significantly higher as reported by the National

to published study authors from Intuitive Surgical®, finding that only 20.8% of authors disclosed payments from Intuitive, and nearly 64% of studies had at least one author who received payment despite no COI indicated. These discrepancies between reported and actual payments correlated with a higher likelihood of recommending robotic surgery [41]. This study was not specific to VHR, many of the articles

cited in this work include statements of payment received from Intuitive Surgical®. While this does not automatically invalidate study findings, the discerning reader should carefully scrutinize study results. Author transparency is paramount.

**Table 1A:** Summary of Clinical Outcomes: IPOM and unspecified rVHR

Clinical outcome	rIPOM	rVHR NOS
Total <i>n</i>	651 [1–3, 13, 15–18, 24, 37, 42]	1893 [12, 23, 25–27]
Operative time	74–180 min [1–3, 13, 16–18, 37, 42]	104.5 min [23]
Defect size	3–6.1 cm [1–3, 15–18, 37]	NR
Fascial closure	0–93% [1, 13, 15–18]	69.30% [12]
Length of stay	0.2–2.5 days [1–3, 13, 15–18, 24, 42]	1.1–4.3 days [12, 23, 25, 27]
SSO/minor complications	0–5% [1, 3, 15, 16, 18]	3.80% [12]
SSI/major complications	0–9% [1–3, 13, 15–18, 24, 37, 42]	0.8–1.7% [12, 26, 27]
Hernia recurrence	0–7.7% [2, 3, 13, 16, 17, 42]	NR

SSO surgical site occurrence, SSI surgical site infection, IPOM intraperitoneal onlay of mesh

**Table 1B:** Summary of clinical outcomes: rTAPP, rTAR/rRVHR, and eTEP

Clinical Outcome	rTAPP	rTAR/rRVHR	eTEP
Total <i>n</i>	93 [36, 37, 43]	285 [14, 39, 40, 44, 45]	37 [46]
Operative time	73–163.7 min [36, 37, 43]	245–365 min [14, 40, 44, 45]	162 min [46]
Defect size	9.7–1219 cm <sup>2</sup> [36, 37, 43]	6.5–13.5 cm [14, 39, 40, 44, 45]	7.4 cm [46]
Fascial closure	100% [36, 43]	96.3–100% [14, 39, 40, 44, 45]	100% [46]
Length of stay	0–1 [36, 43]	1–3.5 days [14, 39, 40, 44, 45]	0.7 days [46]
SSO/minor complications	0–3.7% [36, 37, 43]	0–52.8% [14, 39, 40, 44, 45]	5.40% [46]
SSI/major complications	0 [36, 43]	0–3.8% [14, 39, 40, 44, 45]	0 [46]
Hernia recurrence	0 [36, 43]	NR	NR

SSO surgical site occurrence, SSI surgical site infection, rTAPP robotic transabdominal preperitoneal repair, rTAR robotic transversus abdominis release, rRVHR Robotic retromuscular ventral hernia repair, eTEP extended totally extraperitoneal repair

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## Chapter 7. Key question: treatment of lateral primary or incisional hernias: Which technique should be preferred?

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### Search terms

Lateral abdominal wall hernia, lateral eventration, iliac hernia, subcostal hernia, flank hernia repair, flank hernia repair with mesh, lumbar hernia repair, lumbar hernia repair with mesh, unusual hernias of the abdominal wall, spigelian hernia, spigelian hernia repair, lateral incisional hernia, traumatic lumbar hernia, Grynfeltt OR Grynfeltt's hernia, Petit OR Petit's hernia; the above AND laparoscopy, lumbar hernia AND lumbar muscles AND paralysis, lumbar hernia AND lumbar muscles AND paralysis AND bulge, lumbar hernia AND lumbar muscles AND paralysis AND nephrectomy, lumbar hernia AND nephrectomy.

### Searching machines

PubMed, Embase, and Medline (2000–2018) were searched. For the study of the old guidelines read the original publication in “*Surg Endosc* (2014) 28: page 399–401”.

### New Statements:

Level 2B	Laparoscopic repair of lateral abdominal wall hernias (with mesh) is associated with less surgical site infections, less surgical site occurrences, more intraoperative visceral lesions and an equal rate of recurrences and chronic pain compared to open mesh repair.
Level 4	Laparoscopic repair of large lateral abdominal wall hernias (defect diameter > 15cm) is burdened with higher recurrence rates.

### New Recommendations:

Grade C	Open and laparoscopic mesh techniques can be recommended for the treatment of primary and incisional hernias of the lateral abdominal wall
Grade D	Large lateral abdominal wall hernias (defect diameter > 15cm) should be treated by an open approach

## Introduction

Lateral abdominal wall hernias comprise primary and secondary defects of the lumbar, subcostal, flank, and iliac region (EHS classification). Compared to midline hernias (hernias of the rectus compartment) primary and incisional lateral abdominal wall hernias are rare. Consequently, the evidence guiding the surgical treatment of lateral abdominal wall hernias is scant. The lumbar region is divided into the superior and inferior lumbar space. Primary lumbar hernias of the superior space are denominated Grynfeltt hernia and those of the lower space Petit hernia. The boundaries of the inferior lumbar hernia are the latissimus dorsi muscle posteriorly, the external oblique muscle anteriorly, and the iliac crest inferiorly. The boundaries of the superior lumbar hernia are the 12th rib superiorly, the internal oblique muscle anteriorly, and the erector spinae muscle posteriorly.

Lateral hernias often are located in more than one region of the lateral compartment.

The first IEHS guidelines included 12 papers, 11 case series with more than five patients and one small RCT which included 16 patients and compared open with laparoscopic repair. In total 123 patients were evaluated.

The new literature search (2012–2018) revealed 10 case series (8 retrospective) which included 439 patients on open operations of lateral abdominal wall hernias [1–10] and 4 retrospective case series with 188 patients on laparoscopic repairs ([11–14]; Table 1 + 2).

The level of evidence of all trials was 4 and there were no reports on suture repair. The infection rate after open repair varied between 0 and 25% while no infections were reported after laparoscopic operations. The rate of intraoperative visceral damage was 0 to 4% in open and 0 to 15% in laparoscopic repair, respectively. One retrospective case series of 73 patients with laparoscopic repair of lateral incisional hernias with a medium follow-up of 62 months reported a total recurrence rate of 8% and 25% in the subgroup of subcostal incisional hernias [11]. The authors concluded that a defect size of > 15 cm was a risk factor of recurrence. Only four case series reported on chronic pain [5, 7, 8, 10]. However, according to a systematic review [15] chronic pain rates after open and laparoscopic lateral abdominal wall hernia repair seem to be comparable.

Table 1: Publications on open lateral abdominal wall hernia repair 2012 to 2018 [1–10]

Author	Type of trial	Type of hernia	Type of repair	Number (n)	Complications (%)	Recurrence (%)	Chronic pain (%)	Mean Follow-up months	Miscell.
Moreno-Egea (2015)	Retrospective case series	Complex lateral hernias	Double prosthetic repair	53	25	0	NR	NR	Mean defect diameter 18 cm
Phillips (2012)	Retrospective case series	Flank hernias	Retromuscular	16	25 (Infections $n=3$ , Ureter lesion $n=1$ )	0	NR	17	9 incarcerated hernias
Veyrie (2013)	Retrospective case series	Lateral incisional hernias	Retromuscular with polyester mesh	61 Subcostal 14 Flank 12 Iliac 35	18 ( $n=4$ reoperations)	6.6	NR	47	Mean defect size 56 cm <sup>2</sup>
Luc (2014)	Prospective comparative trial	Lateral incisional hernias	Open retromuscular or IPOM	112 61 after renal transplantation	24 (24.5 after renal transplant. versus 23.5)	10 versus 10	NR		Incisional hernias after renal Tx or no renal Tx
Peres (2014)	Retrospective case series	Subcostal incisional hernias	open	25	33 ( $n=8$ )	4	4		
Blair (2015)	Prospective case series	Lateral incisional hernias	Sublay/underlay with acell dermal matrix	20 (lumbar 10, suprapub. 7, iliac 3)	15	0	NR	24	Mean defect size 270 cm <sup>2</sup>
Pezeshk (2015)	Retrospective case series	Lateral incisional hernias	Sublay/underlay with acell dermal matrix	29	31	3	10	21	

Author	Type of trial	Type of hernia	Type of repair	Number (n)	Complications (%)	Recurrence (%)	Chronic pain (%)	Mean Follow-up months	Miscell.
Purnell (2016)	Retrospective case series	Flank hernias	Open IPOM = 19 Open Interparietal = 12	31	0 infections	3	3	27	
Patel (2016)	Retrospective case series	Lateral Incisional hernias	Open retromus 50%, preperit 41%, IPOM 7% Onlay 2%	61 Subcostal 14 Flank 33 iliac 11 Lumbar 3	SSO 49% SSI 13%	12	NR	15	Mean defect size 79 cm <sup>2</sup>
Renard (2017)	Retrospective case series	Lumbar Incisional hernia	Large Retromus Mesh with large overlap	31	32	7	10		Post Nephrectomy N = 20
Total articles (N = 10)				439					

Table 2: Publications on laparoscopic lateral abdominal wall hernia repair 2012 to 2018 [11–14]

Author	Type of trial	Type of hernia	Type of repair	Number (n)	Complications (%)	Recurrence (%)	Chronic pain (%)	Mean Follow-up months	Miscell.
Moreno-Egea (2012)	Retrospective case series	Lateral Incisional Hernias (subcostal, Iliac, lumbar)	Laparoscopic IPOM	73		8 subcostal 25		62	Predictor for recurrence defect diameter >15 cm
Lal (2014)	Retrospective case series	Lateral Incisional hernias	Laparoscopic IPOM	25 lumbar 5, suprapub 7, iliac 10, subcostal 3	Intraoperative lesions 15%, total 25%	4 (n = 1, iliac)			
Farrarese (2016)	Retrospective case series	Lateral Incisional Hernias (subcostal, flank, Iliac, lumbar)	Laparoscopic IPOM	76					
Novitsky (2017)	Retrospective case series	Traumatic Flank hernias	Laparoscopic IPOM	14	0	0		35	N = 11 chronic incarcerated
Total articles N = 4				188					

## Spiegelhian hernias

### New Statements:

Level 2B	Laparoendoscopic repair of Spiegelhian hernias is superior to open repair because of reduced morbidity rates and length of hospital stay
Level 4	Comparable results are achieved with laparoscopic IPOM and laparoendoscopic preperitoneal techniques

### New Recommendations:

Grade B	For the treatment of Spiegelhian hernias laparoendoscopic mesh repair should be preferred because of lower postoperative morbidity and reduced length of hospital stay.
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The Spiegelhian hernia first escribed anatomically by Adrian van den Spiegel (1578–1625) is located at the level of the semicircular line where the fascias of the oblique and transversus muscles begin to split into separate layers of the abdominal musculature. Spiegelhian hernias (SH) account for 1% to 2% of abdominal wall hernias. Since the advent of minimally invasive surgery laparoscopic methods have become increasingly popular with various techniques being described in the literature. Since 2012 thirtytwo case series with 5 or more patients were included in this review. No randomized-controlled trials on the treatment of SH were identified. One systematic review was published in 2016 [4] which included 237 SHs that were repaired by various techniques. Intraperitoneal onlay mesh technique was the most popular repair method with minimal complications and recurrences reported in all techniques.

### Conclusions

There are a number of laparoscopic techniques available to the surgeon repairing a SH. Overall, laparoscopic repair of the SH is a safe and acceptable method.

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## Chapter 8. Education and training in laparoscopic ventral hernia repair

**D. Lomanto, Hrishikesh P. Salgaonkar**

### Search terms

Hernia/abdominal surgery/Ventral hernia, Umbilical, Incisional hernia, learning curve, Education/Laparoscopy, General surgery/education, Surgical procedures/operative education, Surgical procedures/operative psychology, Teaching/methods, Internship/residency, Competency-based education, Computer assisted instruction.

### Searching machines

PubMed, Embase, Medline and Cochrane Library (2003–2017) were searched for studies for potential inclusion. For the study of the original guidelines read the publication in “*Surg Endosc* (2014) 28:401–403”.

### New publications

In addition to studies included in the published guidelines, total of 5 new studies were found and included in the update. One Level 1 study, one level 2 study, and three Level 3 studies are supplementing the knowledge of Education and training in laparoscopic ventral or incisional hernia repair.

New Statement: identical to previous except statement below:

New Statement: identical to previous except statement below:

Level 3	Residents/trainees show moderate skills decay in difficult tasks, technical surgical skills and knowledge of procedure steps in LVHR and hence dedicated continuous simulation-based assessment and training may help in maintaining skills and performance.
Level 3	Residents and young surgeons benefit from a comprehensive, dynamic and flexible educational program employing multiple medium to enhance surgical skills and patient care in hernia.

Recommendations: No new recommendations.

of published data. *Hernia* 22(2):353–361. <https://doi.org/10.1007/s10029-018-1740-1>. Epub 2018 Jan 27 (2B)

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Comments: We identified one new study defining learning curve in Laparoscopic ventral hernia repair (LVHR) [1]. In this study, results of LVHR performed by three experienced surgeons in a single center were retrospectively analyzed. They found that after 20 cases the overall performance plateaued, most notably in intra and postoperative complications. The operative time stabilized after 12 cases.

The SAGES Hernia task force conducted a study using interviews and online surveys amongst the task force

members, chief residents, fellows, and surgical residents [2]. They commented that the traditional “see one, do one, teach one” method and prevalent methods of training is inadequate for learning hernia repair. In addition to supervised surgery, most trainees prefer new learning methods such as simulation, web-based training, hands on laboratory, and master videos. The consensus was that educational programs should be comprehensive, dynamic, and flexible to employ various media to address the deficits in hernia surgery training and patient care.

D’Angelo et al., in their multi-center study, tried to evaluate effect of time away from clinical work on clinical skills during dedicated research rotations in surgical residency [3]. Simulation-based training in LVHR, along with others procedures was used to assess improvements in perception of skill decay. They concluded that most residents during their research postings expect moderate skills decay in LVHR, and hence suggested to incorporate simulation-based training in the curriculum during dedicated research time or research fellowships to maintain trainees’ surgical skills. Sonnadara et al. similarly suggested that competency-based training rather than time spent in training should be used to assess a surgeon’s skill level [4]. A Cochrane systemic review suggested that virtual reality training when compared to no training or box-trainer training reduces operating time and improves operative performance of surgical trainees with limited laparoscopic experience [5].


In today’s day and age, it is necessary for residency and fellowship training programs to incorporate simulation-based training and virtual reality training in the curriculum along with surgical training under supervision. Specific simulation training for ventral and incisional hernia repair will benefit the trainee to gain hernia specific skills and also prevent skill decay.

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